



High-peak power laser system used in Yb doped LMA fiber



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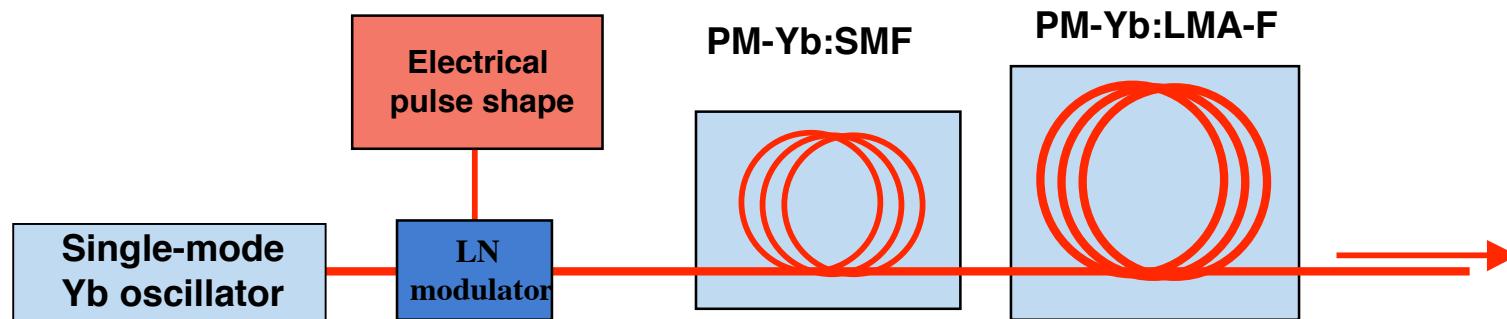


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Sapporo, JAPAN

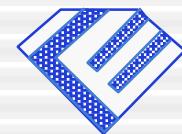
Generation of optional pulse shape by Yb doped fiber laser system for EUV lithography laser

- (1) Introduction
- (2) Development of optional electrical pulse circuit.
- (3) Generation of optional laser pulse.
- (4) PM-Yb Large Mode Area fiber amplifier.
- (5) Conclusion.



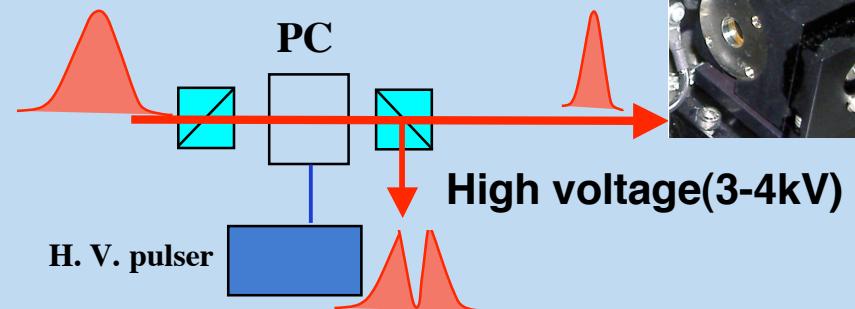


Optional pulse generation by fiber couple LN-modulator

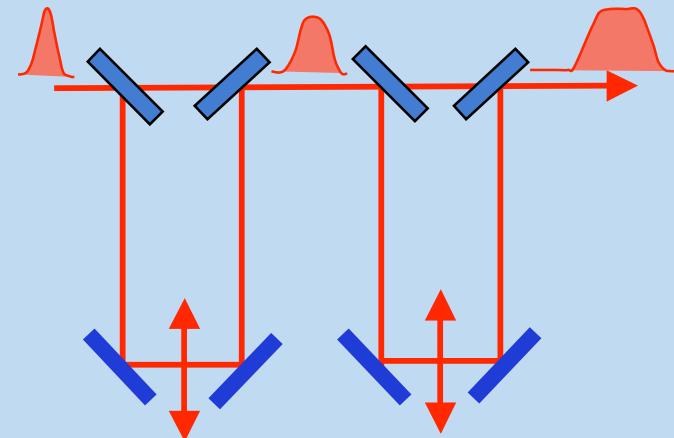


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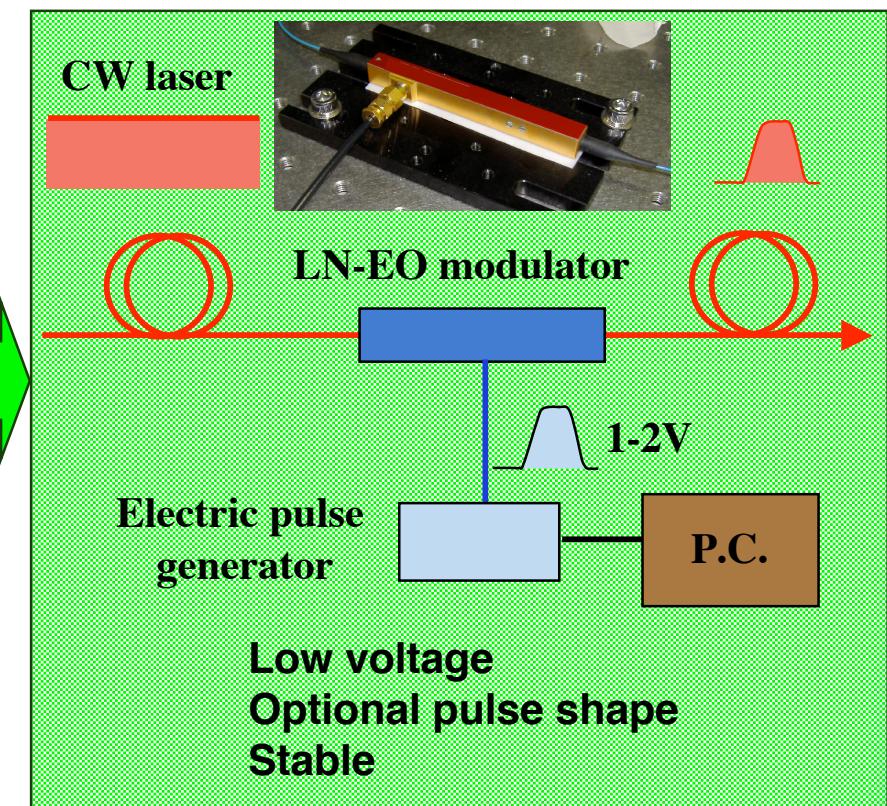
< EO first pockels cell >



< Pulse stacker >

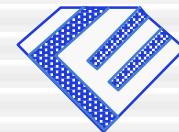


< Fiber couple LN modulator >

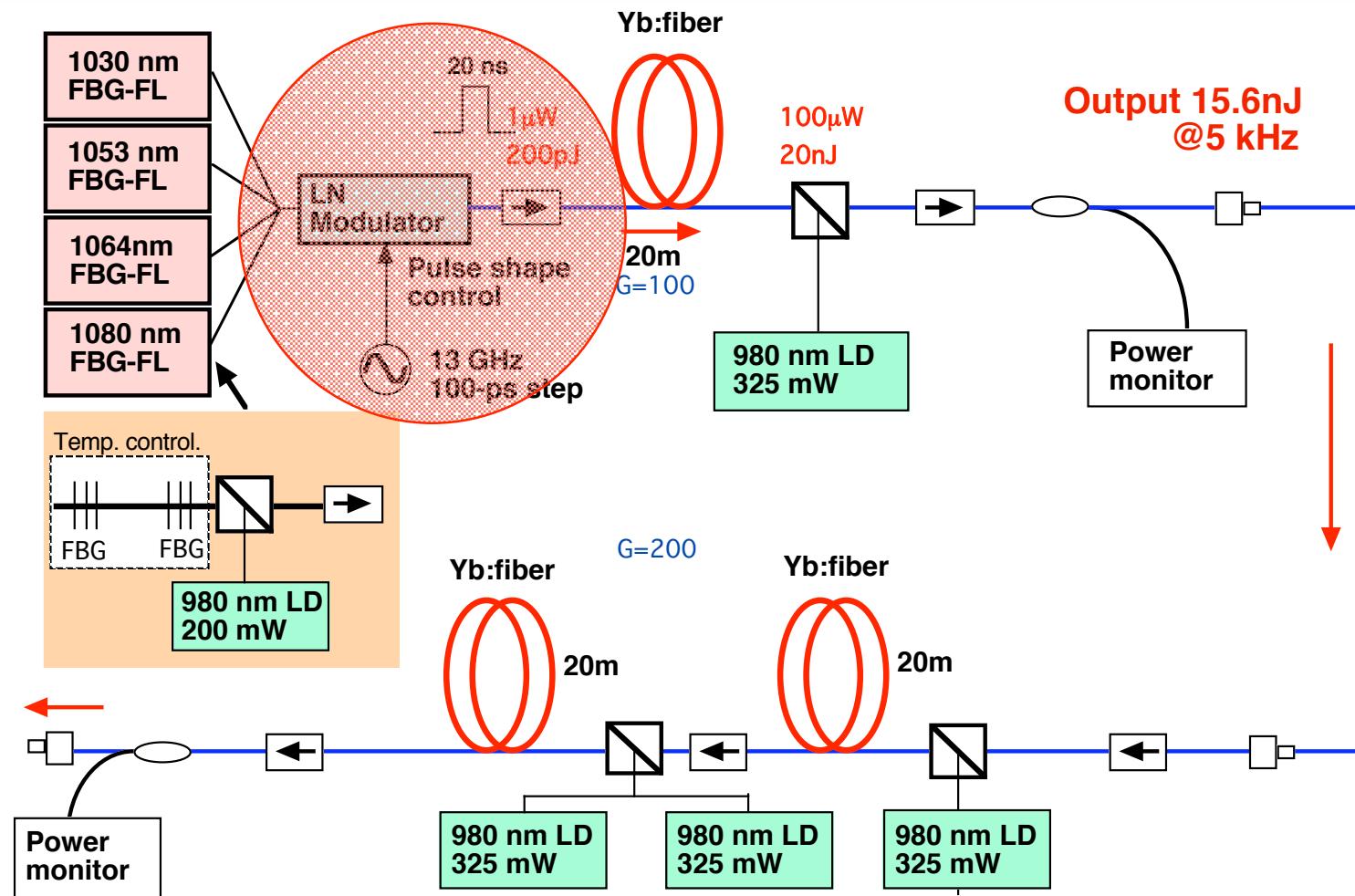




Front-end laser system of single-mode and polarization-maintain Yb fiber laser

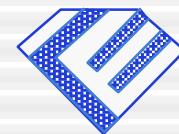


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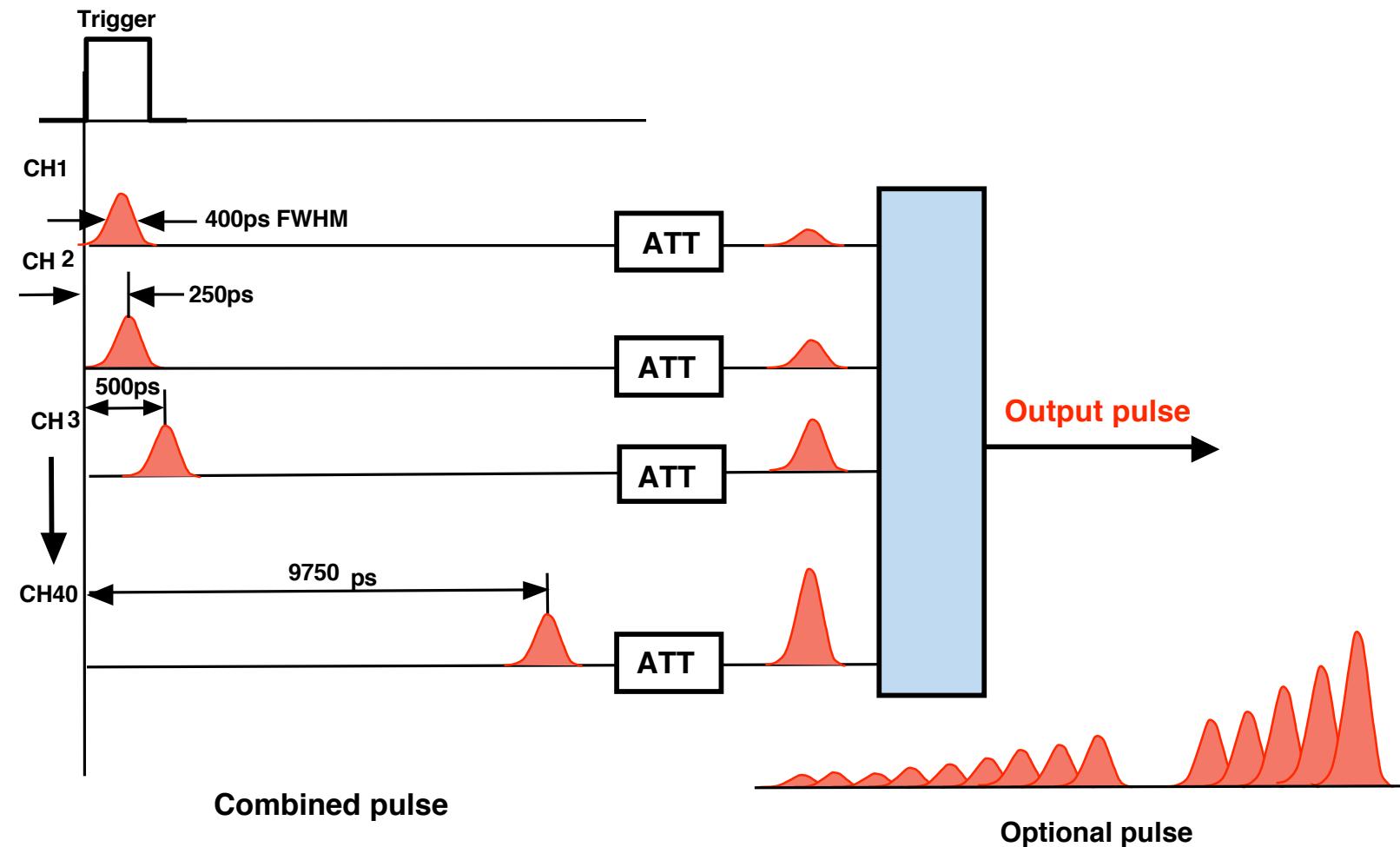




Principle of electrical pulse generation



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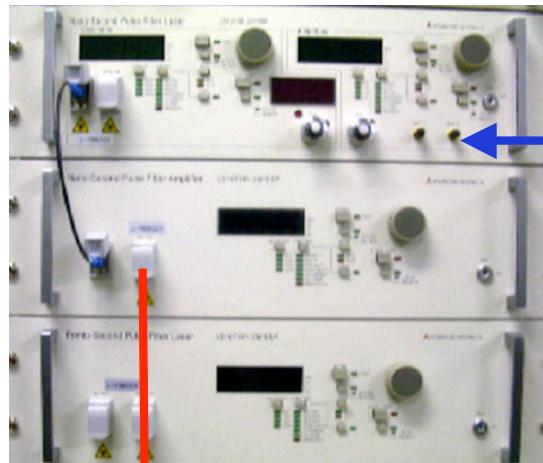
Generation system of optional pulse shape



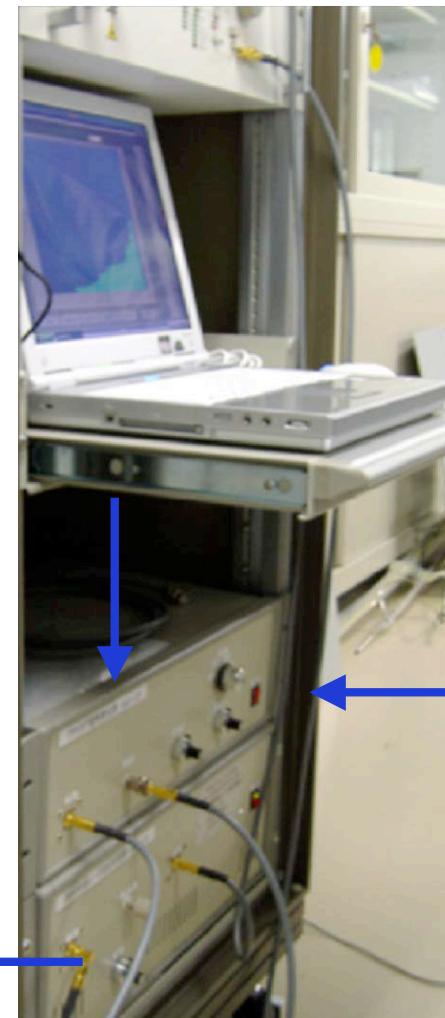
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Generation system of optional pulse shape

Yb:fiber laser system

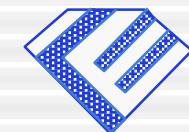


Output

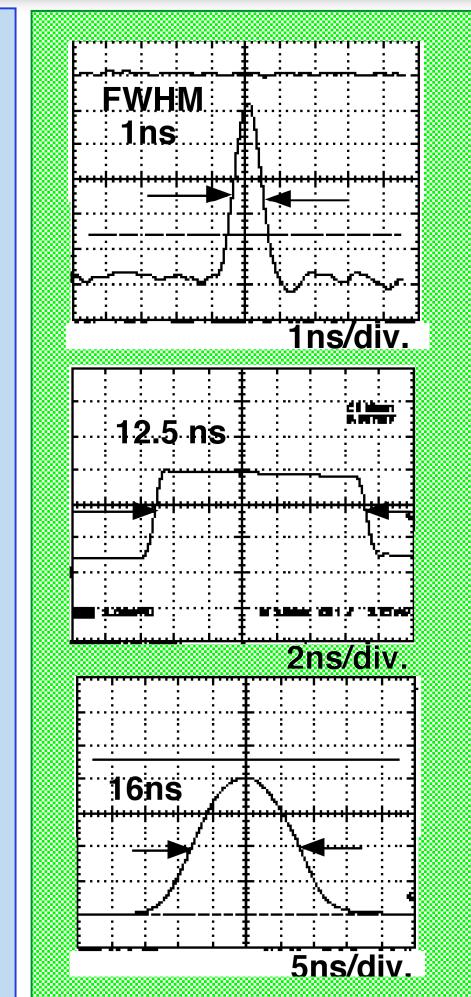
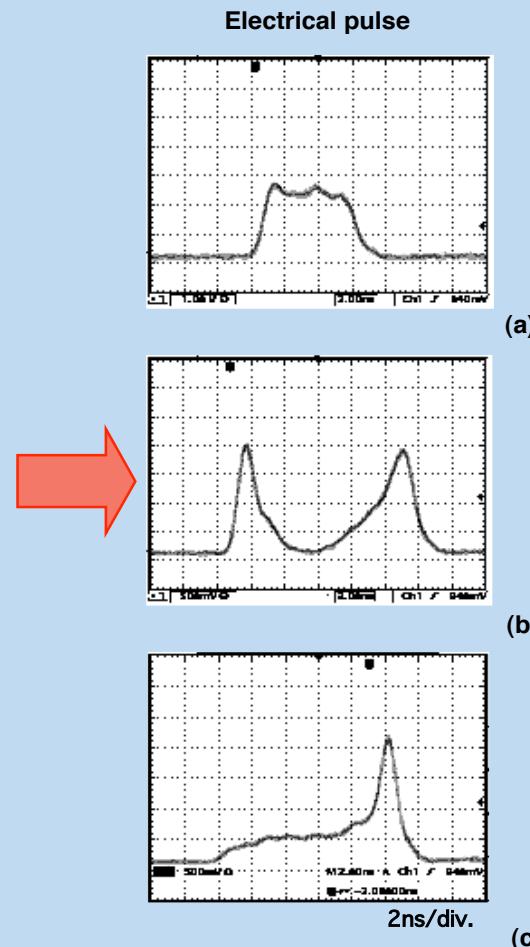
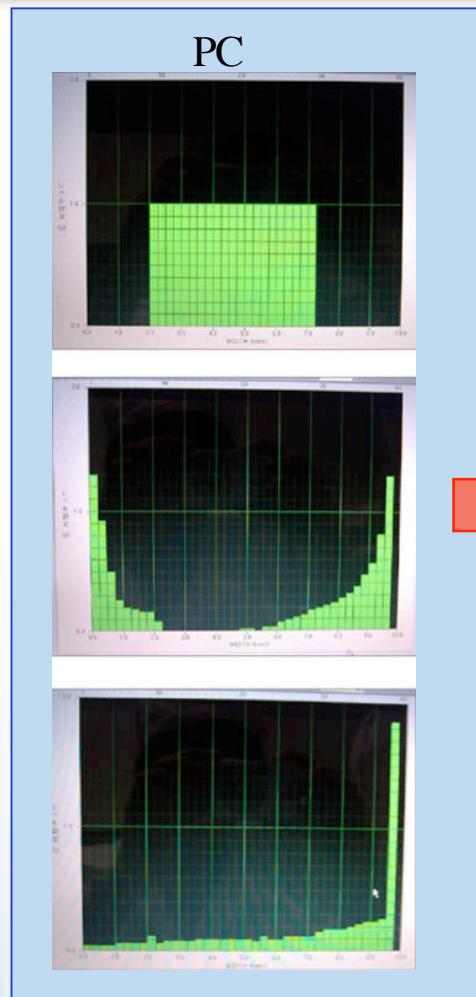




Generation of optional laser pulse corresponding to electrical pulse shape



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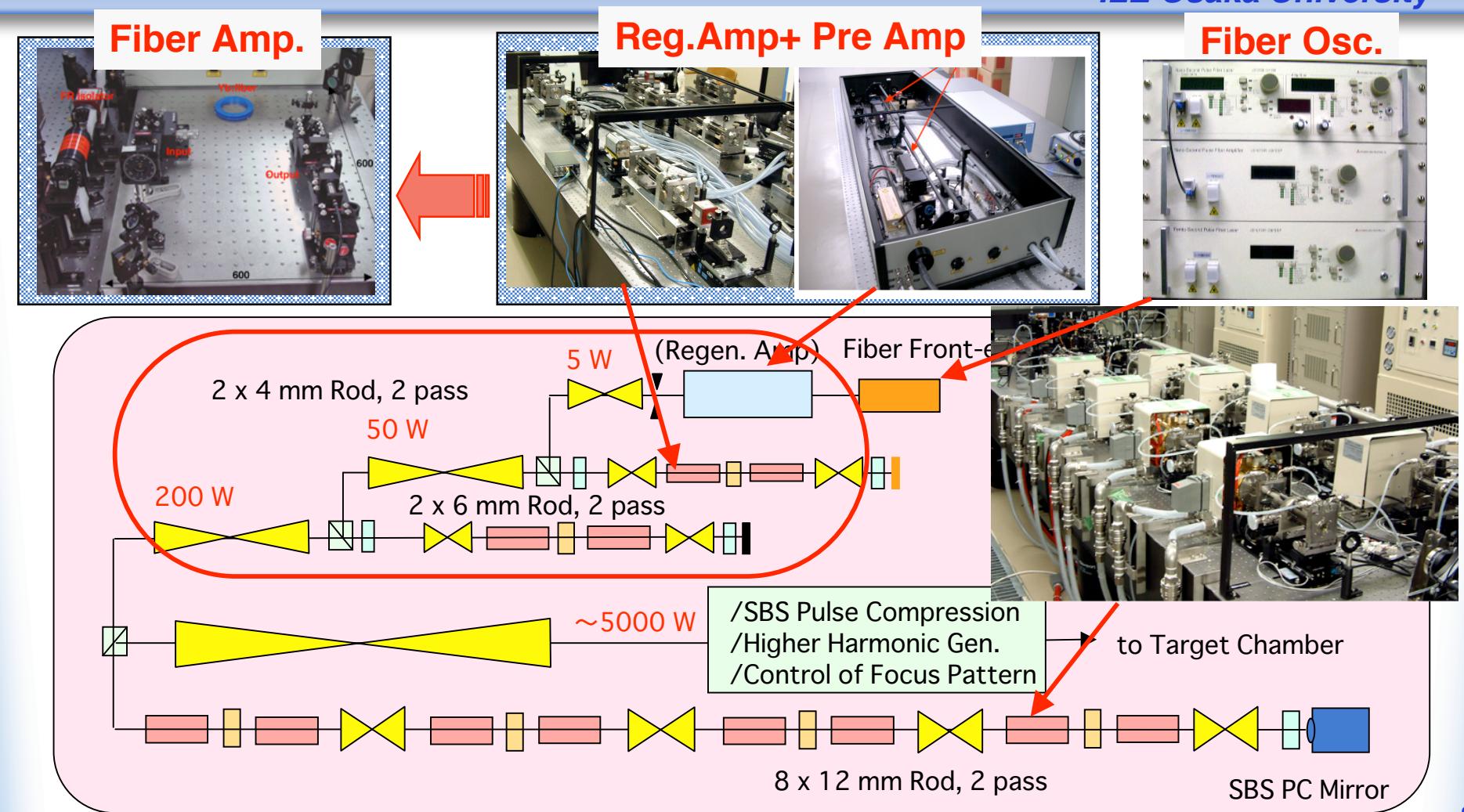




Regenerative amplifier replace to Yb fiber laser for high average Nd:YAG laser.

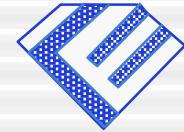


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Comparison with regenerative amplifier and Yb LMA fiber laser



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Regenerative amplifier

Output 5W(1mJ, 5kHz)

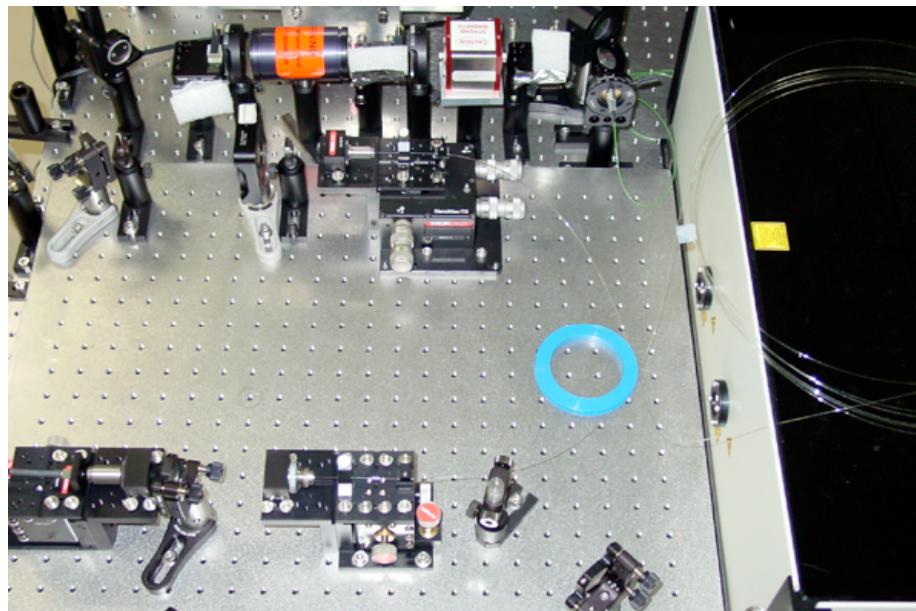
Repetition rate	5kHz (PC limit)
Pulse duration	3 ns (cavity length)
Beam quality	good($M^2=1.5-2$)
Efficiency	low



Yb:fiber(LMA) amplifier

Now : Output 6.6W (66μJ, 100kHz)
In future: Output 30-50W (3-5mJ, 10kHz)

1-100kHz (Repetitious)
Optional pulse shape and width (1-100ns)
Excellent ($M^2=1.1$)
High

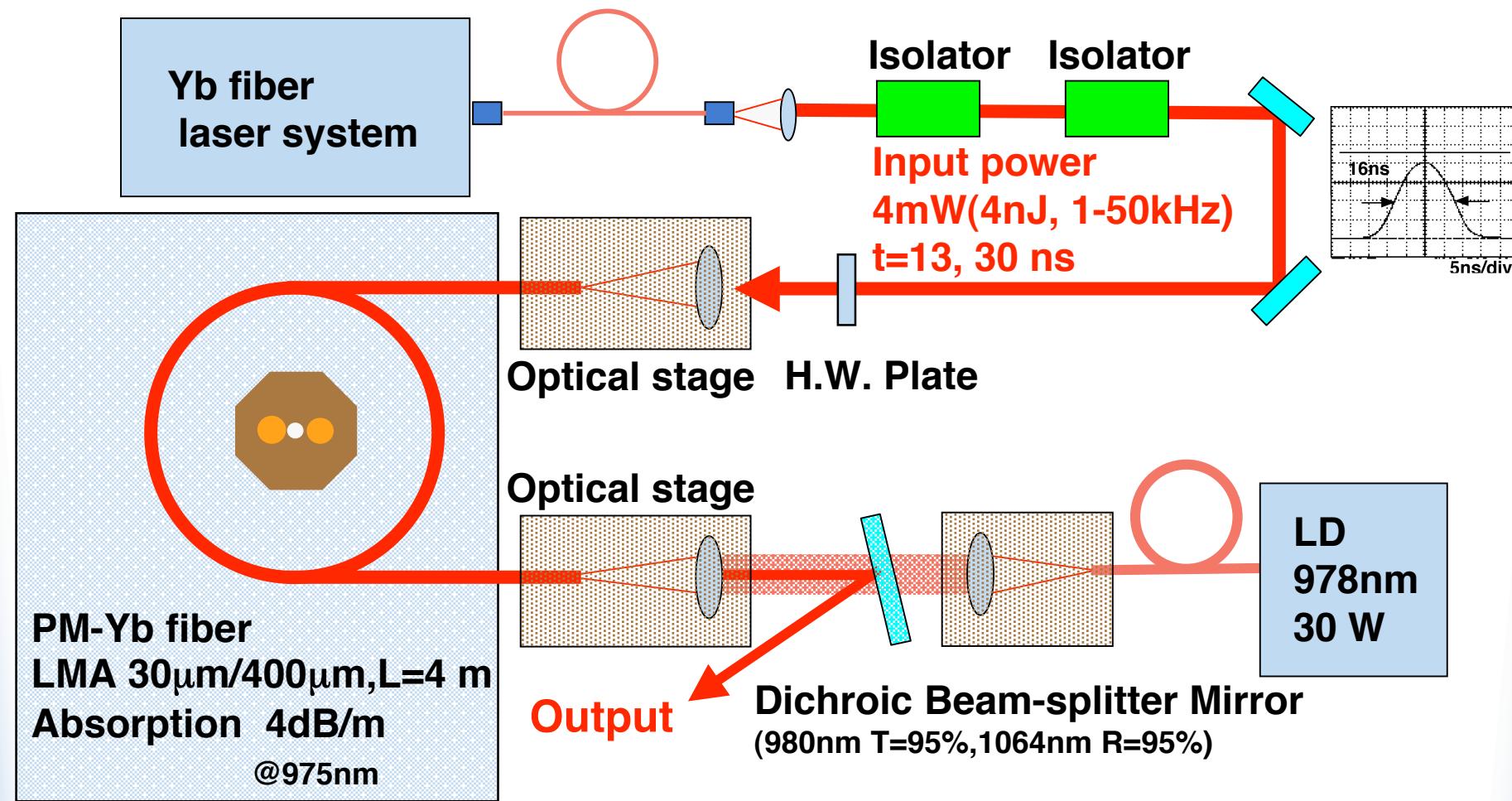




Experimental layout of PM-Yb LMA fiber amplifier



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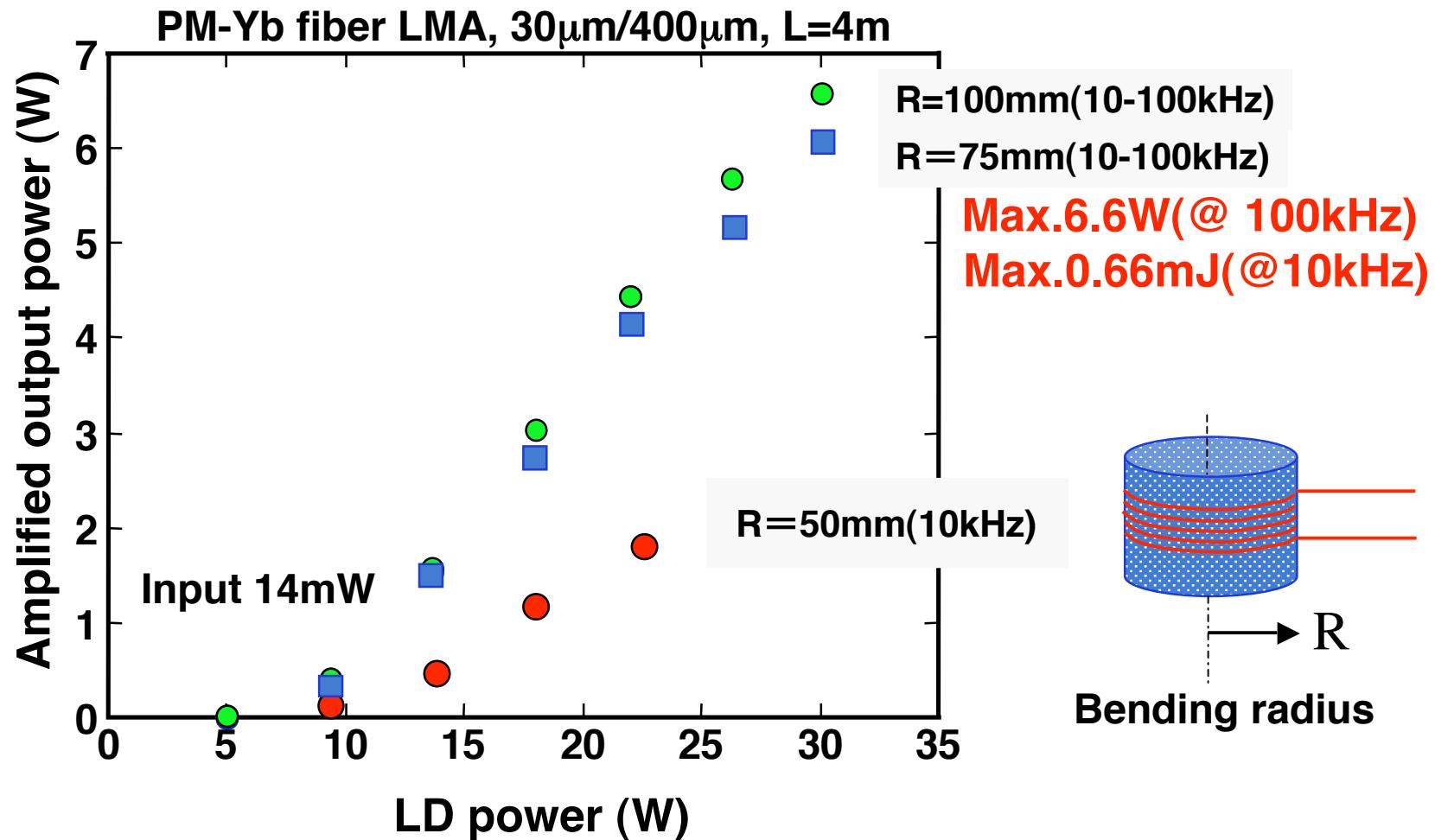




Output power depend on bending radius for PM-Yb LMA fiber amplifier



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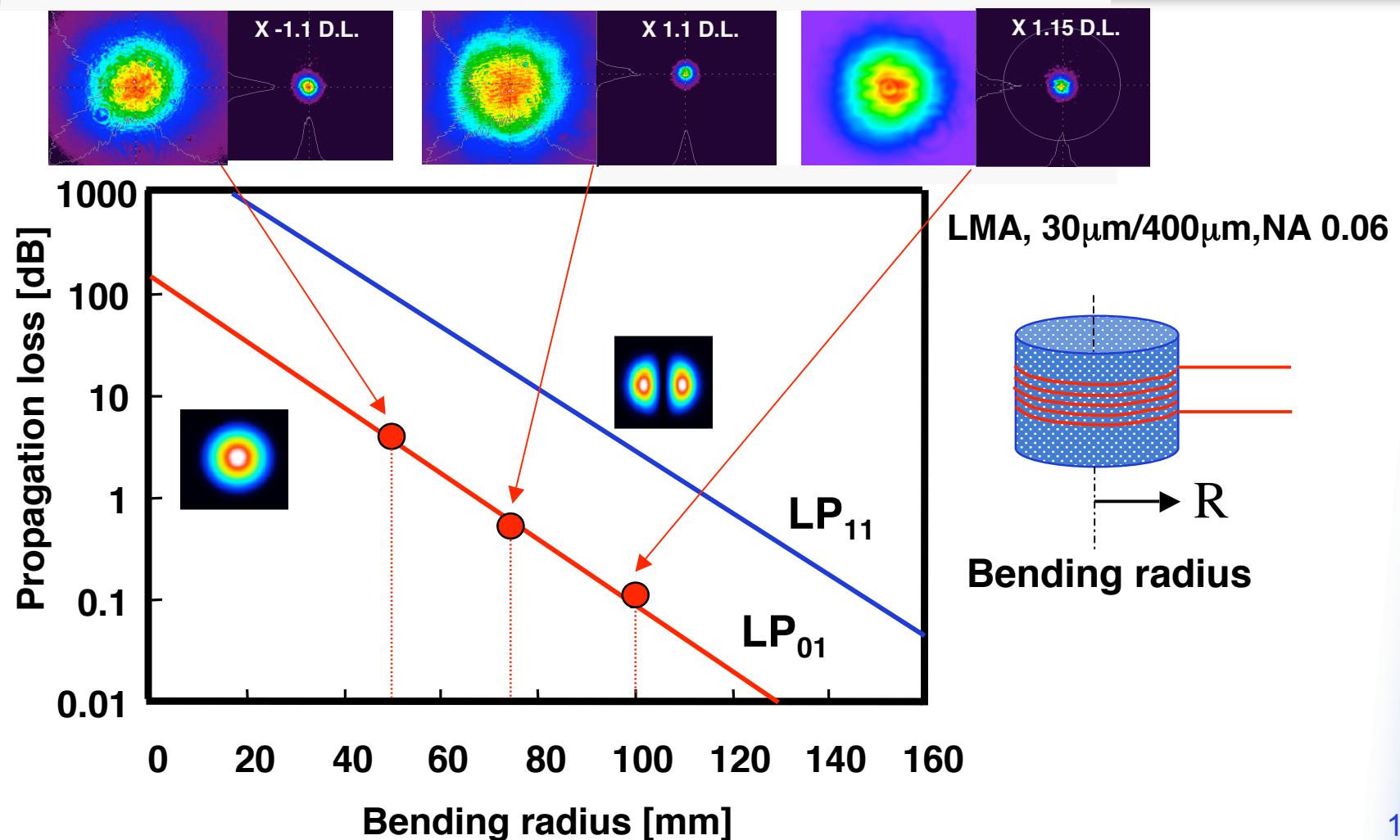




Propagation loss and output beam quality depend on bending radius for PM-Yb LMA fiber amplifier

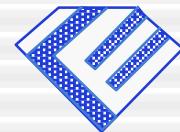


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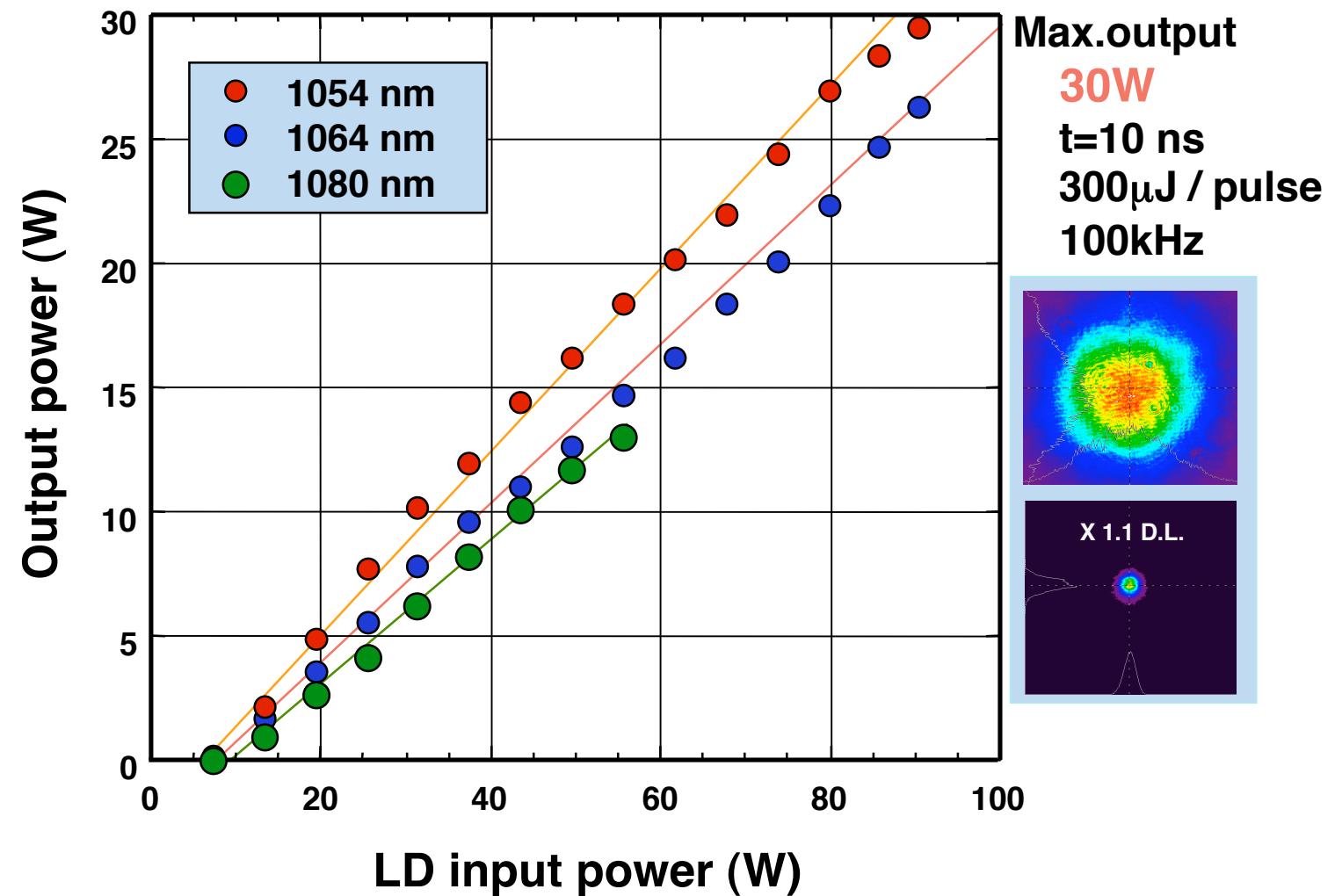




High power operation for PM-Yb LMA fiber amplifier



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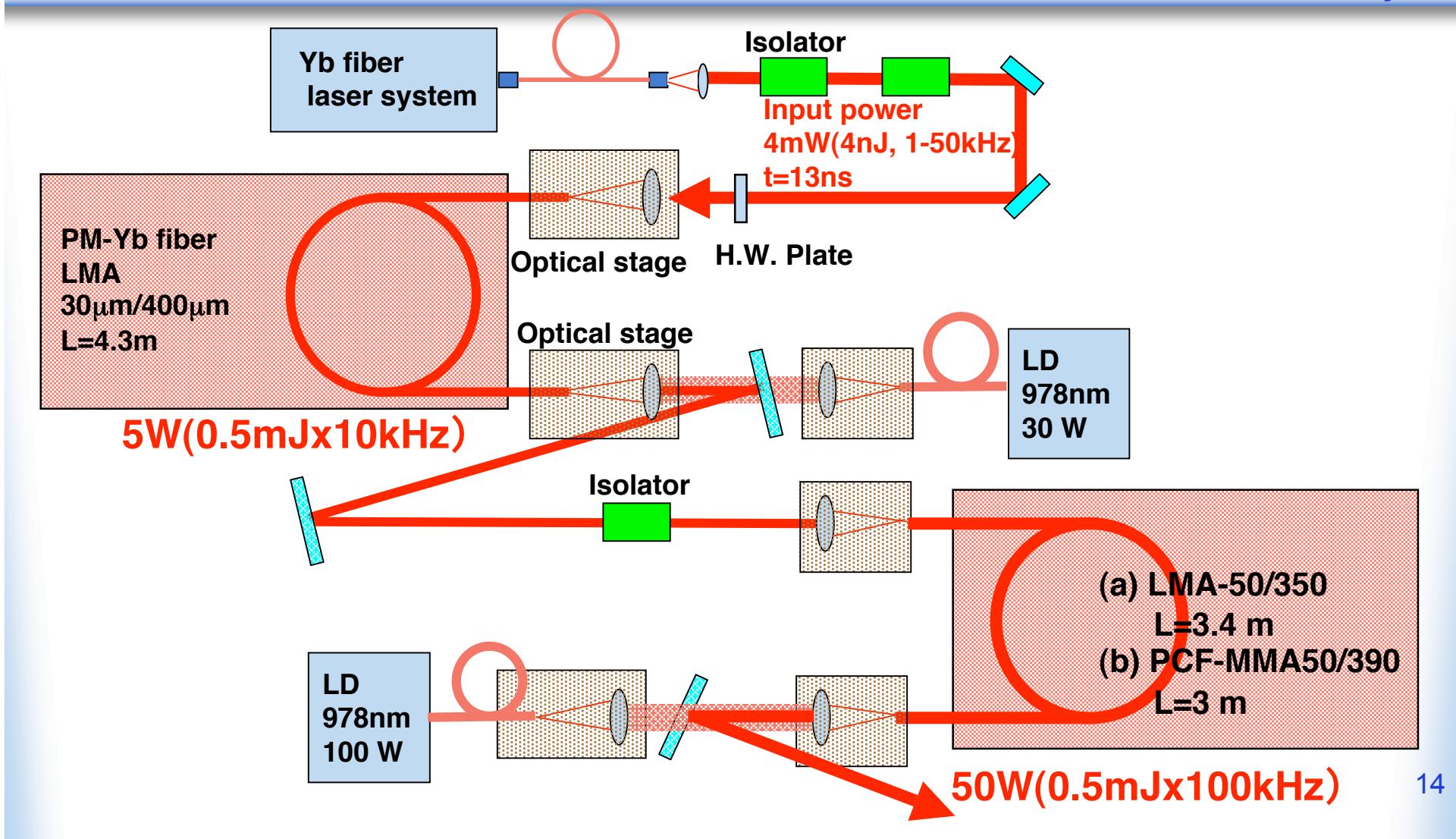




Experimental layout for PM-Yb LMA fiber amplifier(50 W, 0.5mJ, 100kHz)



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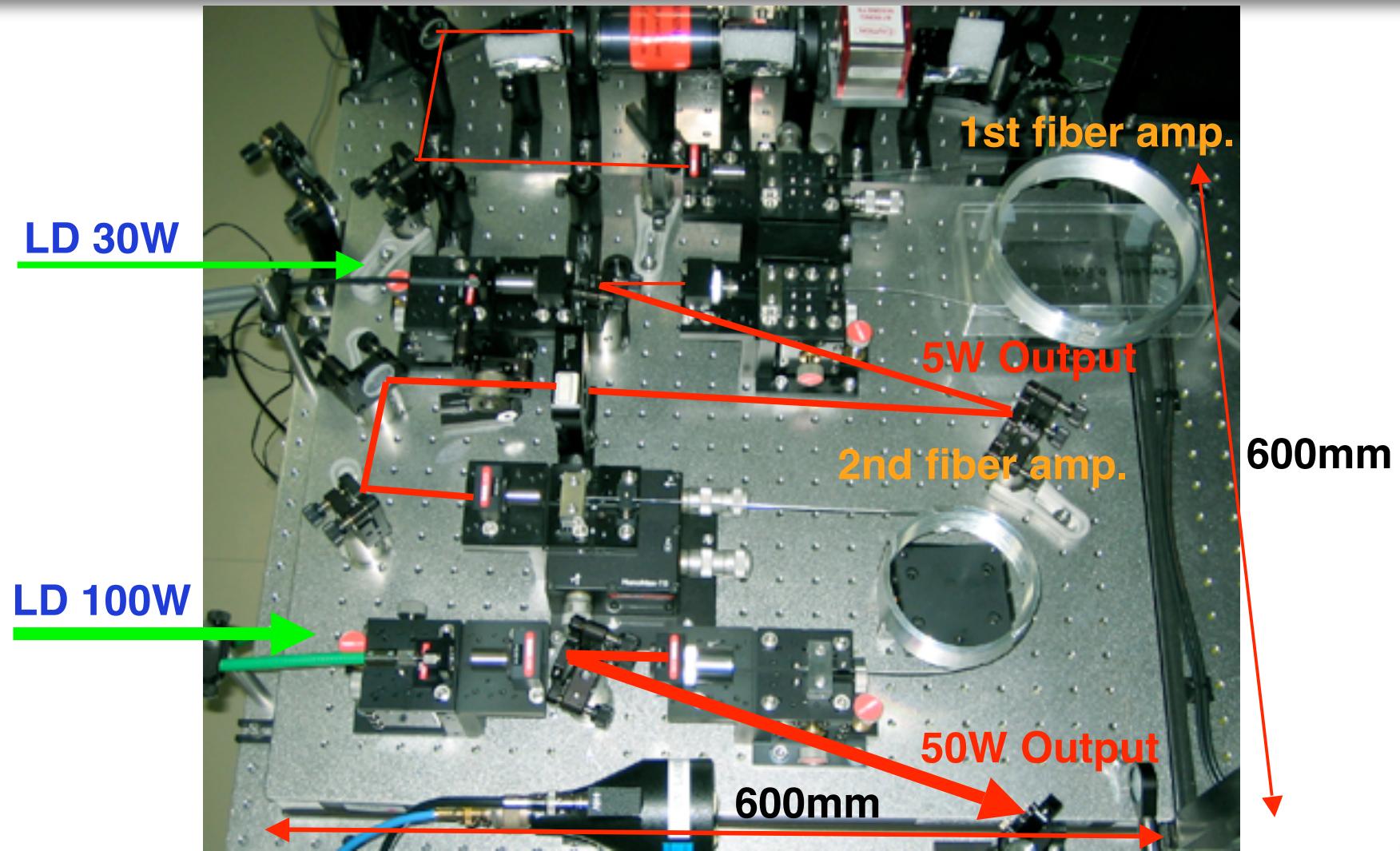




Photograph for PM-Yb LMA fiber amplifier (50 W, 5mJ, 10kHz)



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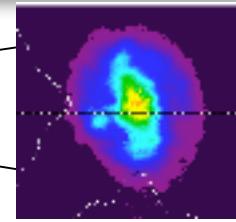
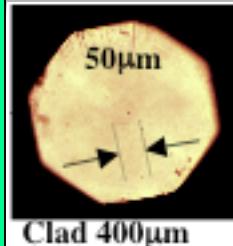


Laser output power and gain characteristics(1)

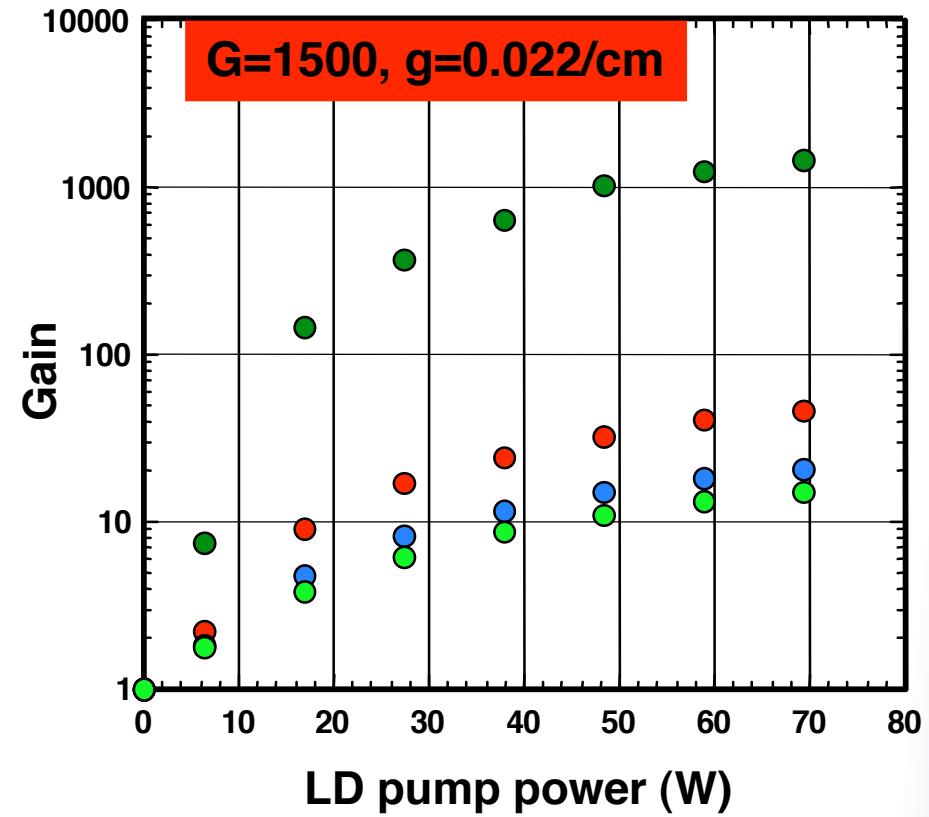
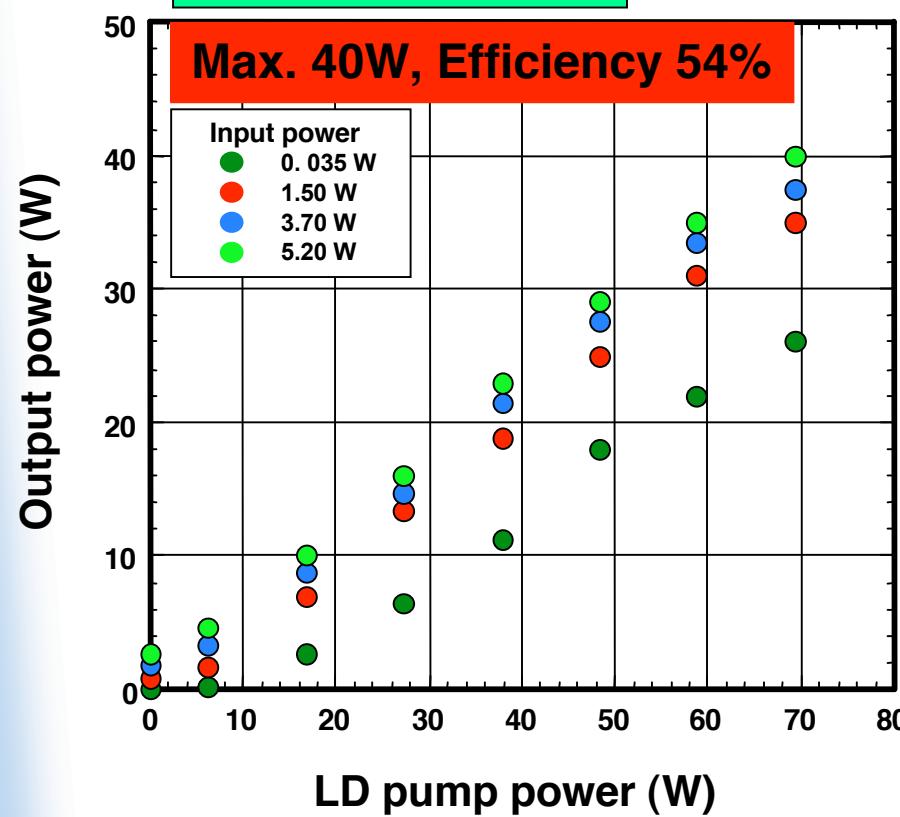


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Core 50 μ m
Clad 350 μ m
NA 0.06, 12dB/m
L=3.4m



Near-field pattern





Conclusion



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Generation of optional pulse shape by Yb doped fiber laser system for EUV lithography laser

- The optional pulse shape generator by **Yb doped fiber laser system**.
- Yb fiber laser system operated the polarization-maintained pulsed for single transverse and -longitudinal mode using fiber Bragg grating (FBG).
- The laser oscillator can be tuned at **four wavelengths of 1030, 1053, 1064 and 1080 nm**.
- This system generates optional pulse shapes that sliced up the Yb fiber oscillator by a LN (LiNbO₃) intense modulator with 12.5-GHz bandwidth.
- The several output waveforms were obtained including **rectangular pulse from 1ns to 12.5 ns with a 500-ps rise time**, and **Gaussian pulse from 1 to 25 ns**.
- The highest output energy of about 250 nJ for 10-ns Gaussian pulse was achieved at 100-kHz repetition rate.
- The output power has been increased **over 30W (300μJ, 100kHz)** by a 30-μm core Yb double-clad polarization-maintained LMA fiber and **57W (570μJ, 100kHz)** by a 50-μm core MMF fiber